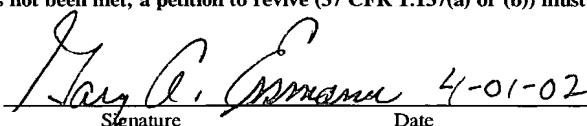
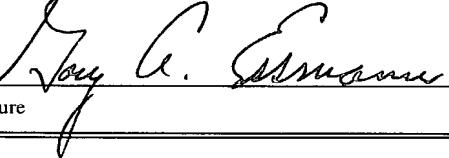


FORM PTO 1390 (REV. 11-2000)	U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		825-164
		U S APPLICATION NO. (if known, see 37 CFR 1.5) 10/089559

INTERNATIONAL APPLICATION NO. PCT/EP00/09705	INTERNATIONAL FILING DATE October 4, 2000	PRIORITY DATE CLAIMED October 4, 1999
TITLE OF INVENTION AXIAL PISTON COMPRESSOR		
APPLICANT(S) FOR DO/EO/US OTFRIED SCHWARZKOPF		
<p>Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> 1. <input type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below. 4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31). 5. <input type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) <ul style="list-style-type: none"> a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> has been communicated by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input checked="" type="checkbox"/> A English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). <ul style="list-style-type: none"> a. <input checked="" type="checkbox"/> is attached hereto. b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4). 7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) <ul style="list-style-type: none"> a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> A English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). 10. <input type="checkbox"/> A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). <p>Items 11 to 20 below concern other document(s) or information included:</p> <ol style="list-style-type: none"> 11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 13. <input checked="" type="checkbox"/> A FIRST preliminary amendment. 14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 15. <input type="checkbox"/> A substitute specification. 16. <input type="checkbox"/> A change of power of attorney and/or address letter. 17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825. 18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). 19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). 20. <input type="checkbox"/> Other items or information: <ul style="list-style-type: none"> <input type="checkbox"/> Applicant claims small entity status. <input checked="" type="checkbox"/> Supplement to Transmittal Letter. 		

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 10/089559	INTERNATIONAL APPLICATION NO. PCT/EP00/09705	ATTORNEY'S DOCKET NUMBER 825-164
21. <input type="checkbox"/> The following fees are submitted:		CALCULATIONS PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.....		\$ 1,040.00
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.....		\$ 890.00
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO		\$ 740.00
International preliminary examination fee (37 CFR 1.482).paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)..		\$ 710.00
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims satisfied provisions of PCT Article 33(1)-(4).....		\$ 100.00
ENTER APPROPRIATE BASIC FEE AMOUNT = \$890.00		
Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 C.F.R. 1.491(3)).		<input type="checkbox"/> 20 <input type="checkbox"/> 30 +130.00
CLAIMS	NUMBER FILED	NUMBER EXTRA
Total Claims	6 - 20 =	-0-
Independent Claims	1 - 3 =	-0-
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		-0- + \$280.00
TOTAL OF ABOVE CALCULATIONS = \$1,020.00		
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.		-
SUBTOTAL = \$1,020.00		
Processing fee of \$130.00 for furnishing the English Translation later than months from the earliest claimed priority date (37 C.F.R. 1.492(f)).		<input type="checkbox"/> 20 <input type="checkbox"/> 30 +
TOTAL NATIONAL FEE = \$1,020.00		
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property		+
TOTAL FEES ENCLOSED = \$1,020.00		
		Amount to be refunded:
		Charged:
a. <input checked="" type="checkbox"/> A check in the amount of \$ 1,020.00 to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 01.2000 . A duplicate copy of this sheet is enclosed. d. <input type="checkbox"/> Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.		
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.		
SEND ALL CORRESPONDENCE TO: ANDRUS, SCEALES, STARKE & SAWALL, LLP 100 East Wisconsin Avenue, Suite 1100 Milwaukee, Wisconsin 53202 Phone: (414) 271-7590 Fax: (414) 271-5770		
 Signature		Date 4-01-02
GARY A. ESSMANN Name		Reg. No. 29,376

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 101089559	INTERNATIONAL APPLICATION NO. PCT/EP00/09705	ATTORNEY'S DOCKET NUMBER 825-164
CERTIFICATE OF EXPRESS MAIL		
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as EXPRESS MAIL-POST OFFICE TO ADDRESSEE, in an envelope addressed to: BOX PCT, COMMISSIONER OF PATENTS AND TRADEMARKS, WASHINGTON, D.C. 20231 on the 1st day of April, 2002. Express Mail Label EV 097314852 US.		
GARY A. ESSMANN Name  Signature	29,376 Reg. No.	April 1, 2002 Date

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of:)
OTFRIED SCHWARZKOPF) AXIAL PISTON COMPRESSOR
)

PRELIMINARY AMENDMENT

Milwaukee, Wisconsin 53202

Box Patent Application
Asst. Commissioner for Patents
Washington, D.C. 20231

Sir:

It is requested that the U.S. national stage examination be carried out on the amended claims dated July 12, 2001. Prior to computing the filing fee in this application, kindly amend the above identified application, as follows. The filing fee is to be computed on the amended claims.

In the Specification:

Beginning at page 1, between the title and the first line of text, the specification has been amended as follows:

CROSS REFERENCE TO RELATED APPLICATION

The present application is the U.S. national stage application of International Application PCT/EP00/09705, filed October 4, 2000, which international application was published on April 12, 2001 as International Publication WO 01/25635 A1. The International Application claims priority of German Patent Application 199 47 677.2, filed October 4, 1999.

In the Claims:

Claim 3 has been amended as follows:

3. Axial piston compressor according to Claim 1, characterized in that the disc is a wobble plate that is rotatably mounted on a swash plate and is set at a tilt angle with respect to the drive shaft that corresponds to the angle of the swash plate.

OTFRIED SCHWARZKOPF

Atty. Docket No. 825-164

Claim 4 has been amended as follows:

4. Axial piston compressor according to claim 1,
characterized in that, given a distance of 30 mm between the long axis (L) of the
drive shaft and the long axis (Z) of the piston, an 8-mm diameter of the flat surface (22) of
the sliding blocks (20), which is opposed to the slideway, and a maximal tilt angle (α) of
18° between the long axis of the drive shaft and the central axis of the disc, the distance
between the mid-plane of the disc and the pivotal axis of the disc (14) is no greater than
about 1 mm.

Add the following new claims:

5. Axial piston compressor according to Claim 2, characterized in that the disc
is a wobble plate that is rotatably mounted on a swash plate and is set at a tilt angle with
respect to the drive shaft that corresponds to the angle of the swash plate.

6. Axial piston compressor according to claim 2,
characterized in that, given a distance of 30 mm between the long axis (L) of the
drive shaft and the long axis (Z) of the piston, an 8-mm diameter of the flat surface (22) of
the sliding blocks (20), which is opposed to the slideway, and a maximal tilt angle (α) of
18° between the long axis of the drive shaft and the central axis of the disc, the distance
between the mid-plane of the disc and the pivotal axis of the disc (14) is no greater than
about 1 mm.

Respectfully submitted,



Gary A. Essmann
(Reg. No. 29,376)

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(414) 271-7590
Atty. Docket No. 825-164

OTFRIED SCHWARZKOPF

Atty. Docket No. 825-164

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Marlene Kubiak

Name

Marlene Kubiak

Signature

Reg. No.

April 1, 2002

Date

3/pr/tv

5

Axial piston compressor

10 State of the art

The invention relates to an axial piston compressor with a drive shaft, a disc mounted on the drive shaft so that it can be tilted relative to the latter about a pivotal axis, and at least one piston provided with sliding blocks that move along a slideway on the disc.

Such an axial piston compressor can be used in particular in an air conditioner for motor vehicles. It serves to suck a coolant out of a heat-transfer compartment, in which the coolant evaporates while taking up heat, and to compress it to a higher pressure so that in another heat-transfer compartment the heat can be given off at a higher temperature level. Subsequently the coolant passes into an expansion organ, where it is returned to the pressure level of the first heat-transfer compartment.

For vehicle air conditioners coolant compressors of various constructions are employed. In recent years, for several reasons, axial piston compressors have come into general use, in particular because this construction enables an energetically favourable regulation of the output. That is, the compressor is customarily coupled directly to the motor by a belt drive, so that the operating conditions of the compressor cannot be adjusted as desired by changing the rotational speed of the compressor; for this reason the output is altered by

tilting the disc, which determines the volume displaced by the compressor piston.

The stroke of each piston is produced by the cooperation between the sliding blocks connected to the piston and the disk, which can be pivoted relative to the drive shaft. When the disk is not tilted with respect to the drive shaft, i.e. the central axis of the disc coincides with the long axis of the drive shaft, there is no stroke, because the distance between, for example, the floor of the cylinder within which the piston is disposed and the bearing surface does not change when the drive shaft rotates. On the other hand, when the disc is tilted so that the angle between the central axis of the disc and the long axis of the drive shaft is different from zero, usually at most 20°, the distance between the bearing surface of the disc and the floor of the cylinder changes periodically between a minimal and a maximal value during each rotation of the drive shaft. Thus when the distance is minimal, the piston coupled to the disc is at its top-dead-centre position, i.e. is inserted maximally into the cylinder, whereas when the distance is maximal, the piston is at bottom dead centre.

The slideway, i.e. the path on the disc surface along which the sliding blocks mounted on the piston move, changes according to the angle at which the disc is tilted.

When the central axis of the disc coincides with the long axis of the drive shaft, the sliding blocks move over the disc along a circular slideway, the radius of which corresponds to the distance between the centre of the sliding blocks and the long axis of the drive shaft. In contrast, when the disc is tilted, the sliding blocks move along an elliptical slideway, because the distance between the middle of the sliding blocks and the long axis of the drive shaft is unchanged. The minor axis of the ellipse has a length corresponding to the radius of the circular slideway on a disc that is not tilted, and is parallel

to the pivotal axis of the disc. The length of the major axis of the ellipse is equal to the radius divided by the cosine of the tilt angle of the disc.

To make the compressor compact, the pivotable disc is
5 dimensioned so that when it is not tilted, there remains only a very small margin between the slideway of the sliding blocks and the outer edge of the disc. As a result, when the disc is tilted, the slideway overlaps the edge of the disc in the regions of the disc that correspond to the upper and the lower
10 dead-centre points. This is a consequence of the apparent shortening of the disc when it is pivoted. Because of the fact that the slideway overlaps the edge when the disc is tilted, the area available to transfer the forces between disc and sliding blocks is reduced. Furthermore, in one of the positions
15 in which the sliding blocks overlap the edge of the disc to the greatest extent, namely the position corresponding to the top-dead-centre point of the piston at the end of the compression stroke, the force exerted between the sliding blocks and the disc is maximal. Because the reduction of the area available
20 for force transfer coincides with the maximum of the force to be transferred, the surface pressure between the disc and the sliding blocks increases, which in the extreme case can cause severe abrasion between these structures.

The objective of the invention is thus to improve an axial
25 piston compressor of the kind described above in such a way that abrasion between the sliding blocks and the disc is reliably prevented under all operating conditions.

Advantages of the invention

In an axial piston compressor in accordance with the invention,
30 with the features cited in the characterizing part of Claim 1, the pivotal axis of the disc is offset from the disc's central plane; as a result, a translational movement is superimposed on the rotational movement of the disc. The consequence is that

when the disc is pivoted, it shifts relative to the sliding blocks, the position of which is fixed. This shifting can be used to alter the amount by which the sliding-block slideway overlaps the edge of the disc to a specific degree, either 5 markedly reducing the overlap or eliminating it entirely. This reduces or eliminates the increase in surface pressure between sliding block and slideway.

Preferably it is provided that the displacement of the pivotal axis of the disc from the mid-plane of the disc is towards the 10 side of the disc that faces the piston. In this configuration the reduction of contact area between the sliding blocks and the disc brought about by tilting of the disc is counteracted in the region corresponding to the top-dead-centre point of the associated piston, i.e. at the operating point at which the 15 force acting on the piston is greatest. The reduction of contact area between sliding block and edge of the disc that does occur in this configuration, which is twice as great as in a configuration according to the state of the art (with a pivotal axis that coincides with the mid-plane of the disc), 20 can be tolerated because at the corresponding time the force acting on the piston is comparatively slight. Even though the contact area between sliding blocks and disc surface is reduced, the resulting surface pressure is below the critical values.

25 According to one preferred embodiment of the invention the disc is a swash plate, which can be set into rotation by the drive shaft and the tilt angle of which with respect to the drive shaft can be adjusted. Such an axial piston compressor, which – apart from the translational movement that is superimposed on 30 the rotational movement of the disc – corresponds to the structure known for example from the patent DE 197 03 216 A1, combines the advantage obtained in accordance with the invention, namely a reduction of surface pressure at certain times during operation such as the time when the force acting

on the piston is maximal, with the advantage of relatively simple construction that this kind of structure provides.

According to an alternative preferred embodiment it is provided that the disc is a wobble plate, which is rotatably mounted on 5 a swash plate and the tilt angle of which with respect to the drive shaft corresponds to that of the swash plate. This kind of structure, which – apart from the translational movement of the wobble plate that is superimposed on the rotational movement during pivoting – corresponds to a structure known for 10 example from the patent DE 196 21 174 A1, combines the advantage of a targeted reduction of surface pressure with the advantage of particularly low-friction operation that this kind of structure provides.

According to a preferred embodiment of an axial piston 15 compressor in accordance with the invention it is provided that with a distance of 30 mm between the long axis of the drive shaft and the long axis of the piston, an 8-mm diameter of the flat surfaces of the sliding blocks, which are apposed to the disc, and an angle of maximally 18° between the long axis of 20 the drive shaft and the central axis of the disc, the distance between the mid-plane of the disc and the pivotal axis of the disc is about 1 mm. With this slight offset between pivotal axis and disc mid-plane, when the disc is tilted it is displaced relative to the slideway of the sliding blocks only 25 far enough that on one side of the disc the degree to which the slideway overlaps the outer edge of the disc is reduced. Although it is theoretically possible to shift the disc so far that the slideway is confined entirely to the disc in the region of one dead-centre point of the piston, the invention is 30 not intended to produce this effect; as the distance by which the pivotal axis is offset from the mid-plane of the disc increases, the centre of mass of the disc also moves away from the long axis of the drive shaft. The value given above, if the geometric relationships are as described, represents a good

compromise between a reduction of surface pressure on one hand and an increased imbalance of the disc on the other hand.

Advantageous embodiments of the invention will be apparent from the subordinate claims.

5 Drawings

In the following the invention is explained with reference to the attached drawings, wherein

- Figure 1 is a schematic sectional view of an axial piston compressor according to the state of the art;

10 - Figure 2 shows the detail II in Figure 1 on a larger scale;

- Figure 3 is a diagram of the force acting on the piston as a function of angle of rotation;

15 - Figure 4 shows schematically the geometry between disc and sliding blocks in an axial piston compressor according to the state of the art;

- Figure 5 is another schematic drawing to show the geometric relationships in an axial piston compressor according to the state of the art; and

20 - Figure 6 is a schematic drawing of the geometric relationships in an axial piston compressor according to the invention.

Description of the exemplary embodiment

Figure 1 shows an axial piston compressor according to the state of the art. It contains a housing 10 within which a drive shaft 12 is rotatably mounted. To the drive shaft 12 there is 25 attached a swash plate 14, so that it cannot rotate on the

shaft but can be pivoted about a pivotal axis C. The pivotal axis C intersects the long axis L of the drive shaft 12 at a right angle. The swash plate 14 can be pivoted about the axis C between an essentially untilted position, in which the angle 5 between the mid-plane M of the swash plate 14 and a plane perpendicular to the long axis L of the drive shaft is about zero, and a maximally tilted position in which the angle α is about 20° . The means by which the change of position of the swash plate 14 is achieved and controlled are, firstly, 10 generally known and furthermore are not relevant to understanding the invention, so that they will not be discussed here.

Within the housing there are several cylinders 16, in each of 15 which a piston 18 is movably disposed. The long axis Z of each piston and each cylinder is parallel to the long axis L of the drive shaft. The compressor can be provided with up to seven such pistons, which are arranged around the drive shaft at uniform angular distances from one another.

Each piston is provided with two sliding blocks 20, each of 20 which comprises a circular flat surface 22 and a rotating surface 24 in the shape of a section of a sphere. The rotating surface of each sliding block 20 is seated within a correspondingly shaped receptacle 26 on the piston, in such a way that the swash plate 14 is retained between the flat 25 surfaces 22 of the two sliding blocks of a piston, which face one another and are oriented in parallel. Accordingly, when the swash plate 14 is tilted at an angle α that is different from zero, the wobbly rotational movement of the swash plate is converted into a translational movement of the piston 18. In 30 this process the flat surfaces 22 of the sliding blocks 20 run along slideways on the swash plate 14 that change position as the tilt angle α is changed. When the central axis of the swash plate 14 coincides with the long axis L of the drive shaft 12, so that the swash plate 14 extends perpendicular to the drive 35 shaft 12, the sliding blocks 20 move along a circular slideway

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on the swash plate 14. The radius of this slideway corresponds to the distance between the centre of the ball-and-socket joint on each cylinder defined by the receptacles 26 and the long axis L. Because in the exemplary embodiment shown here the 5 centre of each ball-and-socket joint coincides with the long axis Z of each cylinder 16, the radius of the slideway corresponds to the distance between the long axis Z and the long axis L. In contrast, when the swash plate is pivoted out 10 of its position perpendicular to the drive shaft 12, the result is an elliptical slideway. The reason is that at the two dead-centre points of the piston, which are shown in Figure 1, each flat surface is at a greater distance from the pivotal point C of the swash plate 14 than when it is in the intermediate positions, 90° away from the dead-centre points.

15 To save space, the outside diameter A of the swash plate 14 is made such that in its untilted position the swash plate projects only slightly beyond the radially outer side of the sliding blocks 20; therefore, because when the swash plate 14 is tilted, its outside diameter appears to be shortened to the 20 value A', the slideways of the sliding blocks 20 are no longer completely on the swash plate. Hence the flat surface 22 of the sliding block is no longer completely in contact with the swash plate 14. The amount by which the flat surface 22 projects beyond the outer edge of the swash plate 14 is indicated in the 25 figures by "a". Figure 4 shows the situation at the moment when the piston passes through the upper and the lower dead-centre point with the swash plate 14 tilted at the angle α . In Figure 5 is a projection of a sliding block 20 and the swash plate 14 onto a plane perpendicular to the long axis L of the drive 30 shaft 12 at the moment of passage through a dead-centre point of the piston. It is clear that the sliding block 20 extends beyond the periphery of the disc 14 by the distance a. Given a distance of 30 mm between the long axis Z of the piston and the long axis L of the drive shaft 12, an 8-mm diameter of the flat 35 surface 22 of the sliding blocks 20, and a maximal tilt angle α of 18°, the geometric relationships are such that the overlap

distance $a = 1.6$ mm. Hence the area \bar{U} of the part of the surface not in contact with the swash plate 14 is 7.2 mm^2 , whereas the remaining area R , which does contact the swash plate 14, is 43 mm^2 . This means that almost 14.4% of the flat surface 22 of the sliding blocks 20 is not available for force transfer, so that the surface pressure in the region of the remaining area R increases accordingly. Matters are made worse by the fact that at each of the dead-centre points the flat surfaces 22 are tilted relative to the long axis Z of each cylinder, so that for the momentarily prevailing surface pressure the only area available is that of the projection of the flat surfaces onto a plane perpendicular to the long axis Z . Furthermore, when each piston is at its top-dead-centre point the force acting between that piston and the swash plate is maximal. In the diagram shown in Figure 3, the force F acting on the piston is plotted as a function of the angle of rotation φ of the swash plate 14. The rotation angle $\varphi = 0^\circ$ corresponds to the top-dead-centre point of a piston, i.e. the position in which it is inserted maximally into the cylinder 16. Starting from top dead centre, the piston is first accelerated in the direction of bottom dead centre, and coolant is simultaneously sucked in. For this reason, the forces acting on the piston are negative in some regions. Once the bottom-dead-centre point has been reached, i.e. at an angle of $\varphi = 180^\circ$, the compressive piston stroke occurs: the piston is accelerated towards top dead centre, causing the coolant to become compressed. During this process the forces that act on the piston are intensified, becoming maximal shortly before the top-dead-centre point is reached.

From this description of the changing force acting on the piston, in connection with the geometric relationships, it will be evident that the proportion of the flat surfaces 22 that is available for force transfer is minimal in the region of the lower dead-centre point, i.e. in the region of the transition from suction stroke to compression stroke. However, here the increase in surface pressure brought about by the fact that

only part of the flat surface 22 makes contact with the swash plate 14 is not critical, because in this region relatively small forces are being transferred. In the region of the top-dead-centre point the flat surfaces of the sliding blocks
5 project just as far beyond the edge of the swash plate 14, but it is here that the strongest forces must be transferred between the swash plate 14 and the sliding blocks 20; hence there is a critical increase in surface pressure between the flat surface 22 in this position and the corresponding part of
10 the swash plate 14. This surface pressure can become so great as to cause severe abrasion between the swash plate 14 and the flat surface 22 of the sliding block 20.

The increased surface pressure just described, between the sliding blocks 20 and the swash plate 14 in the top-dead-centre
15 region of the associated piston, can be reduced or eliminated by the configuration in accordance with the invention, which is shown schematically in Figure 6. In contrast to the configuration known in the state of the art, here the pivotal axis C is offset from the mid-plane of the swash plate 14 by
20 the dimension V. The offset V is such that the pivotal axis C is situated on the side of the swash plate 14 that faces the pistons (not shown in Fig. 6) that it drives. Because of the offset V, when the swash plate 14 is pivoted it makes a translational as well as a rotational movement. As a result,
25 the outer edge of the swash plate 14 is eccentrically disposed with respect to its position at the dead-centre points of the pistons. By this means, the slideway 20 of the sliding blocks is again entirely confined to the surface of the swash plate 14 in the top-dead-centre region of the associated piston; the
30 overlap distance a is equal to zero. Hence the entire area of the flat surface 22 is made available for transferring force. Set against this benefit is the fact that the overlap of the sliding block is doubled in the part of the slideway corresponding to the low-pressure point of the piston movement;
35 however, the resulting increase in surface pressure is

uncritical, because in the region of this low-pressure position of the piston only slight forces must be transferred.

In Figure 6 the offset V of the pivotal axis C from the mid-plane of the swash plate 14 is exaggerated; in practice, given 5 the above-mentioned dimensional relationships, an offset V of the order of 2 mm suffices to eliminate the overlap a at the top-dead-centre point of the piston.

Because of the reduced surface pressure between the sliding blocks and the swash plate under maximal load, the sliding 10 block can in some circumstances be constructed with smaller dimensions, which enables the whole assembly to be made more compact. Furthermore, because the flat surface 22 of the sliding blocks 20 no longer projects beyond the edge of the swash plate 14 under maximal load, tension peaks and hence the 15 wear and tear resulting from edge pressures are reduced. In the bottom-dead-centre region, the increased overlap a of the flat surface 22 improves the coverage of the flat surfaces of the sliding blocks by the lubricant mist in the interior of the housing 10.

20 When the pivotal axis C is disposed eccentrically with respect to the mid-plane of the swash plate, pivoting of the swash plate 14 causes the centre of mass of the swash plate to be eccentric with respect to the long axis L of the drive shaft. The result is a tendency towards slight imbalance while the 25 compressor is in operation. Because these imbalances become more severe as the offset V increases, it can be provided as a compromise that the overlap a in the top-dead-centre region is not compensated entirely but only to such an extent that the surface pressure rises by a negligible amount. For example, 30 with the geometric dimensions described above, an offset V of 1 mm will reduce the surface pressure in the top-dead-centre region by about 10% in comparison to the state of the art, while at the same time the centre of mass of the swash plate 14

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is shifted away from the long axis L of the drive shaft by only 0.3 mm.

The principle in accordance with the invention described above, namely the tilting of a disc about a pivotal axis disposed eccentrically with respect to the mid-plane of this disc, can of course also be applied to axial piston compressors in which the sliding blocks of the pistons do not interact directly with the swash plate itself, but rather make contact with a wobble plate rotatably mounted on the swash plate.

10 List of reference symbols

- 10: Housing
- 12: Drive shaft
- 14: Swash plate
- 16: Cylinder
- 15 18: Piston
- 20: Sliding block
- 22: Flat surface
- 24: Rotating surface
- 26: Receptacle
- 20 A: Outside diameter of swash plate
- A': Apparent outside diameter of swash plate
- C: Pivotal axis
- L: Long axis of drive shaft
- R: Remaining surface
- 25 Ü: Overlapping surface
- V: Offset
- Z: Long axis of piston and cylinder
- α: Tilt angle
- φ: Rotational angle of swash plate

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Claims

1. Axial piston compressor with a drive shaft (12) for a disc (14) that is mounted on the drive shaft in such a way that it can be tilted relative to the drive shaft about a pivotal axis (C), and at least one piston (18), wherein the pivotal axis (C) of the disc (14) is disposed eccentrically with respect to the mid-plane of the disc,
5 characterized in that the piston (18) is provided with at least two sliding blocks (20) that move along the disc (14) on a slideway, arranged such that the piston (18) encloses the sliding blocks (20) in a C-shaped structure, and that the position of the pivotal axis (C) relative to the mid-plane of the disc is on the side that faces the the piston (18), so that the disc (14) can be moved relative to the
10 sliding blocks (20) in such a way that the slideway of the sliding blocks projects beyond the the edge of the disc only slightly or not at all.
15
2. Axial piston compressor according to Claim 1,
20 characterized in that the disc is a swash plate (14), which can be set into rotation by the drive shaft (12) and can be adjusted to various tilt angles (α) with respect to the drive shaft.
3. Axial piston compressor according to Claim 1 or 2,
25 characterized in that the disc is a wobble plate that is rotatably mounted on a swash plate and is set at a tilt angle with respect to the drive shaft that corresponds to the angle of the swash plate.

4. Axial piston compressor according to one of the preceding claims,
characterized in that, given a distance of 30 mm between
the long axis (L) of the drive shaft and the long axis (Z)
5 of the piston, an 8-mm diameter of the flat surface (22) of
the sliding blocks (20), which is apposed to the slideway,
and a maximal tilt angle (α) of 18° between the long axis
of the drive shaft and the central axis of the disc, the
distance between the mid-plane of the disc and the pivotal
10 axis of the disc (14) is no greater than about 1 mm.

ABSTRACT

Axial piston compressor

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In an axial piston compressor with a drive shaft (12), a disc (14) that is mounted on the drive shaft in such a way that it can be tilted relative to the drive shaft about a pivotal axis (C), and at least one piston (18) provided with sliding blocks (20) that move along the disc (14) on a slideway, the objective 10 is to reduce the maximal surface pressure acting between the disc (14) and the sliding blocks (20). For this purpose it is provided that the pivotal axis (C) of the disc (14) is disposed eccentrically with respect to the mid-plane of the disc.

15

Figure 6

VERSION WITH MARKINGS TO SHOW CHANGES MADE

Attorney Docket No. 825-164

In the Specification:

Please add the following paragraph at page 1, between the title and the first line of text as follows:

CROSS REFERENCE TO RELATED APPLICATION

The present application is the U.S. national stage application of International Application PCT/EP00/09705, filed October 4, 2000, which international application was published on April 12, 2001 as International Publication WO 01/25635 A1. The International Application claims priority of German Patent Application 199 47 677.2, filed October 4, 1999.

In the Claims:

Claim 3 has been amended as follows:

3. (amended) Axial piston compressor according to Claim 1 ~~or 2~~, characterized in that the disc is a wobble plate that is rotatably mounted on a swash plate and is set at a tilt angle with respect to the drive shaft that corresponds to the angle of the swash plate.

Claim 4 has been amended as follows:

4. (amended) Axial piston compressor according to ~~one of the preceding claims~~ claim 1,

characterized in that, given a distance of 30 mm between the long axis (L) of the drive shaft and the long axis (Z) of the piston, an 8-mm diameter of the flat surface (22) of the sliding blocks (20), which is ~~apposed~~ opposed to the slideway, and a maximal tilt angle (α) of 18° between the long axis of the drive shaft and the central axis of the disc, the distance between the mid-plane of the disc and the pivotal axis of the disc (14) is no greater than about 1 mm.

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro(43) Internationales Veröffentlichungsdatum
12. April 2001 (12.04.2001)

PCT

(10) Internationale Veröffentlichungsnummer
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(84) Bestimmungsstaaten (regional): ARIPO-Patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), eurasisches Patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI-Patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

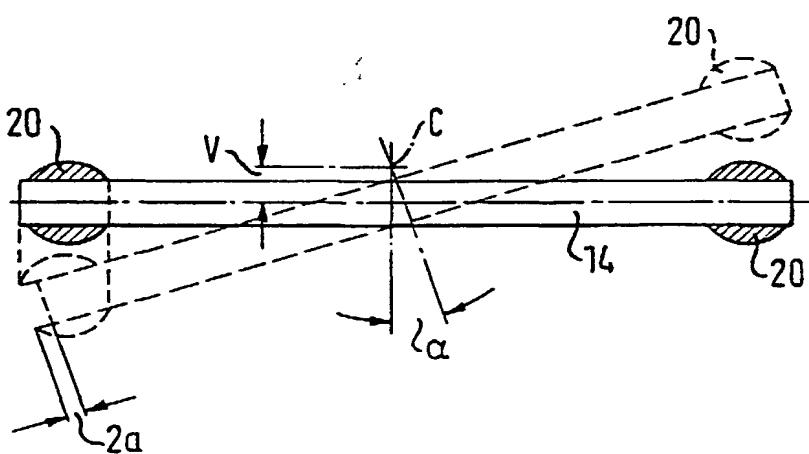
Veröffentlicht:

— Mit internationalem Recherchenbericht.

Zur Erklärung der Zweibuchstaben-Codes, und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

(54) Title: AXIAL PISTON DISPLACEMENT COMPRESSOR

(54) Bezeichnung: AXIALE KOLBENVERDICHTER



(57) Abstract: The invention relates to an axial piston displacement compressor, comprising a drive shaft (12), a disc (14) which is mounted on the drive shaft in such a way, that it can be pivoted about a pivotal axis (C) and at least one piston (18) which is provided with sliding blocks (20) that slide on a runway on the disc (14). The invention aims to reduce the maximum effective surface pressure between the disc (14) and the sliding blocks (20). To this end, the pivotal axis (C) of the disc (14) is located eccentrically in relation to the central plane of the disc.

(57) Zusammenfassung: Bei einem Axialkolbenverdichter mit einer

Antriebswelle (12), einer Scheibe (14), die auf der Antriebswelle so gelagert ist, dass sie relativ zur Antriebswelle um eine Schwenkachse (C) verschwenkt werden kann, und mindestens einem Kolben (18), der mit Gleitsteinen (20) versehen ist, die auf einer Laufbahn auf der Scheibe (14) gleiten, soll die maximal zwischen der Scheibe (14) und den Gleitsteinen (20) wirkende Flächenpressung verringert werden. Zu diesem Zweck ist vorgesehen, dass die Schwenkachse (C) der Scheibe (14) exzentrisch bezüglich der Mittelebene der Scheibe angeordnet ist.

WO 01/25635 A1

10/08959

AXIAL PISTON COMPRESSOR

Inventor: Otfried Schwarzkopf

Attorney Docket No. 825-164

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FIG. 1
(Prior Art)

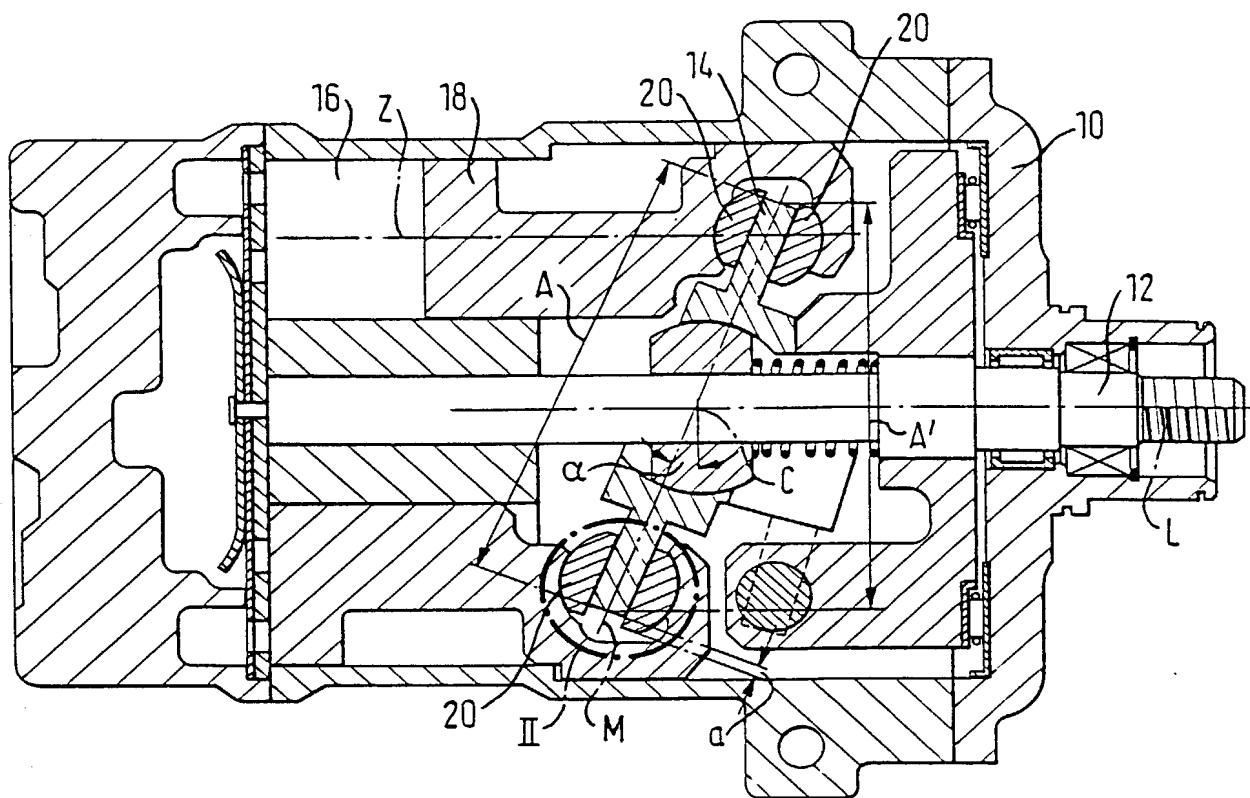
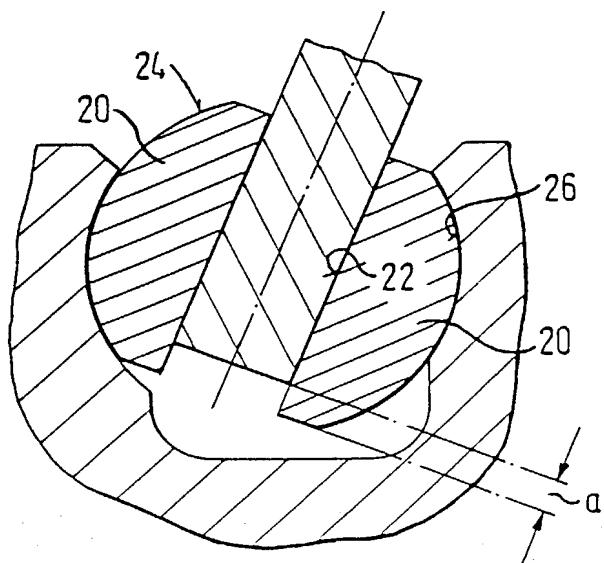
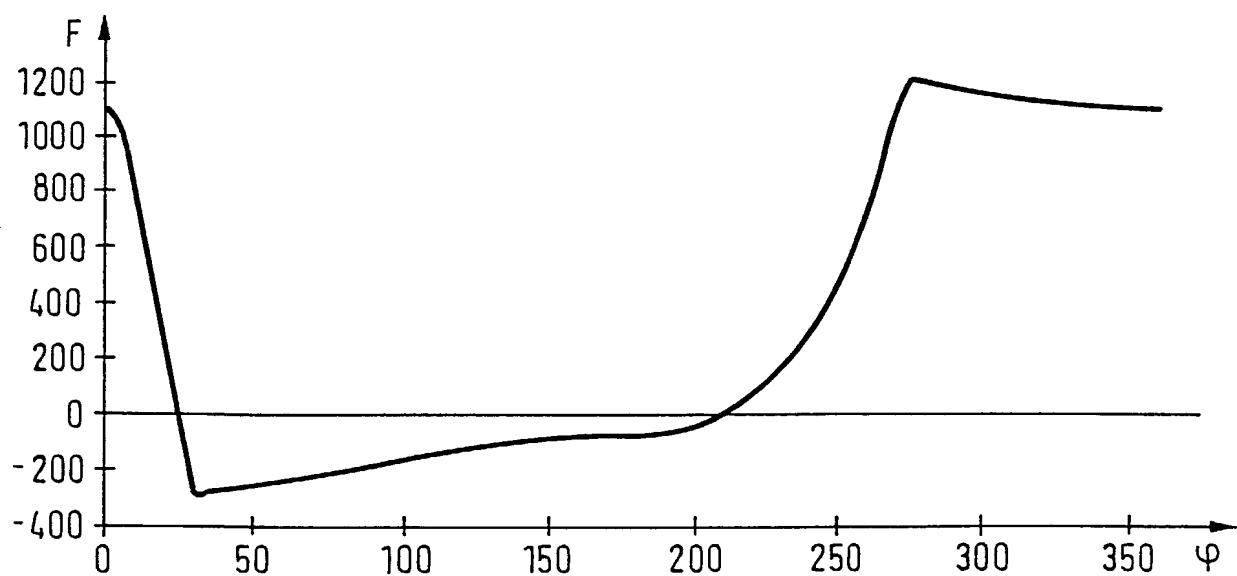


FIG. 2



2 / 3

FIG. 3



3/3

FIG. 4

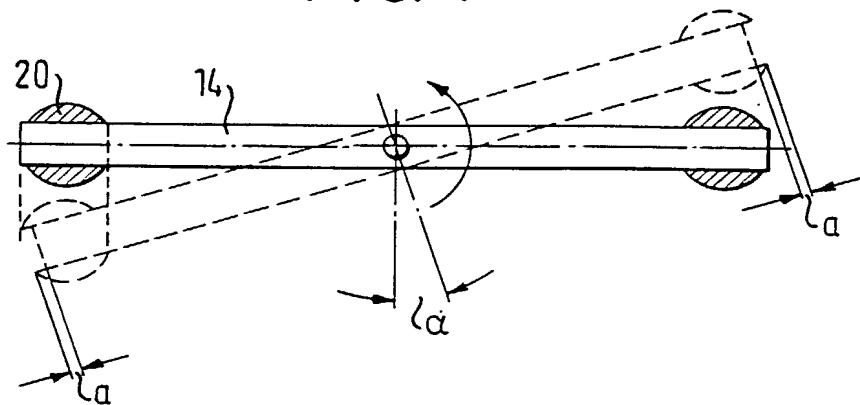


FIG. 6

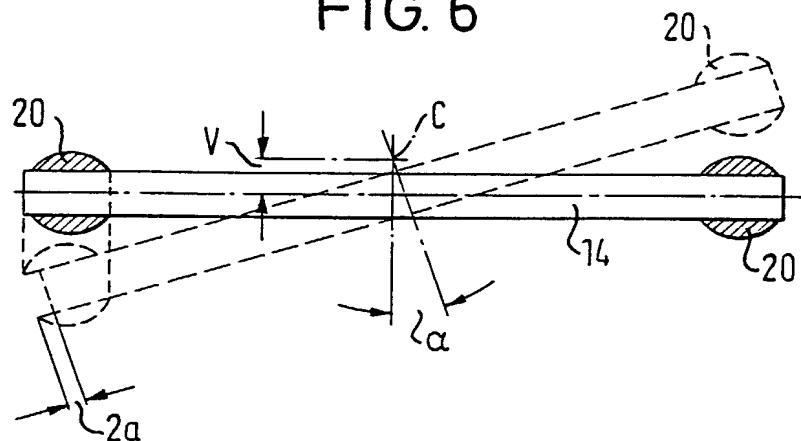
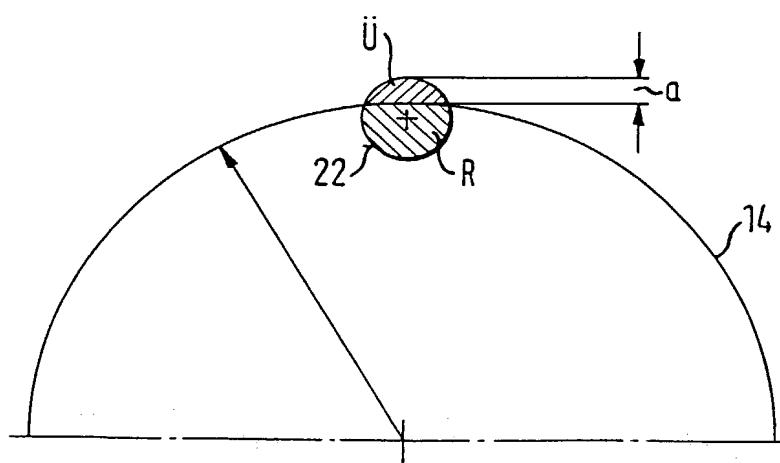


FIG. 5



10/089559 08 JUL 2002

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Approved for use through 9/30/00

Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

PTO/SB/01 (8/96)		Attorney Docket Number	825-164
		First Named Inventor	Otfried Schwarzkopf
COMPLETE IF KNOWN			
DECLARATION		Application Number	
Declaration OR Declaration		Filing Date	
<input type="checkbox"/> Submitted with Initial Filing		Group Art Unit	
<input checked="" type="checkbox"/> Submitted after Initial Filing		Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

AXIAL PISTON COMPRESSOR

(Title of the Invention)

the specification of which
 is attached hereto

OR

 was filed on (MM/DD/YYYY) October 4, 2000 as United States Application Number or PCTInternational Number PCT/EP00/09705 and was amended on (MM/DD/YYYY) July 7, 2001

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Copy Attached? YES NO
199 47 677.2	Germany	10/04/99	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>

 Additional foreign application numbers are listed on a supplemental priority sheet attached hereto:

I hereby claim the benefit under Title 35, United States Code §119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	Additional provisional Application numbers are listed on a supplemental priority sheet attached hereto.

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DECLARATION

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365C of any PCT international application designated the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States of PCT International application in the manner provided by the first paragraph of Title 35, United States Code §112. I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

Additional U.S. or PCT international application numbers are listed on a supplemental priority sheet attached hereto.
As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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George H. Solveson	25,927	William L. Falk	27,709
Gary A. Essmann	29,376	Jeffrey S. Sokol	35,686
Thomas M. Wozny	28,922		
Michael E. Taken	28,120		
Joseph J. Jochman, Jr.	25,058		

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])

Family Name or Surname

OTFRIED

SCHWARZKOPF

Inventor's Signature

Otfried Schwarzkopf

Date

29/05/02

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